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SEQUESTRATION PARTNERSHIP

A New Energy Future for Montana, Idaho, South Dakota, Wyoming, the Pacific Northwest and the Nation

Carbon Sequestration in Reactive Geologic Sinks: Big Sky Carbon Sequestration Partnership Phase II Activities

RW Smith[1], TL McLing[2], BP McGrail[3], EP Robertson[2], JM Boyles[4]
[1]Univ Idaho, [2]Idaho Natnl Lab, [3]Battelle PNWD, [4]Univ Wyoming

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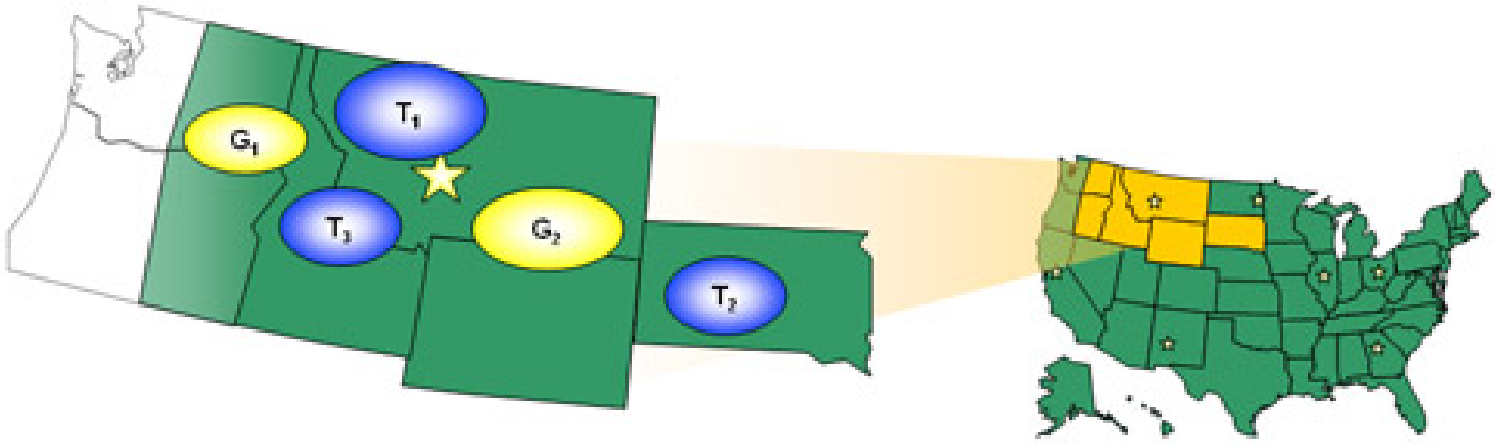
Big Sky Carbon Sequestration Partnership

- One of seven DOE funded partnerships focused on validating the most promising regional opportunities to deploy sequestration technologies
- Thursday May 11 8:25 AM
  - The Regional Partnerships Move on to Evaluate Potential Sequestration Sites



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BSCSP Geologic Approach

- Take advantage of reactive properties of CO_2
  - Identify sequestration targets with multiple trapping mechanisms
  - Emphasize mineral or other chemical reaction trapping
- Develop robust geologic sequestration options to permanently store CO_2
    - Sorption to regional abundant coal
    - Conversion to alkalinity and carbonate minerals

Reactive Trapping of CO_2

$$CO_2^{sc} + H_2O \Leftrightarrow H_2CO_3^{aq}$$

$$H_2CO_3^{aq} \Leftrightarrow H^+ + HCO_3^-$$

$$\begin{matrix} Me_2SiO_4 \\ 2Me_2(CO_3)_2 \end{matrix} + 4H^+ \Rightarrow 2Me^{2+} + \begin{matrix} H_4SiO_4^{aq} \\ 2Me^{2+} + 4HCO_3^- \end{matrix}$$

$$2Me^{2+} + 4HCO_3^- \Rightarrow Me_2(CO_3)_2$$

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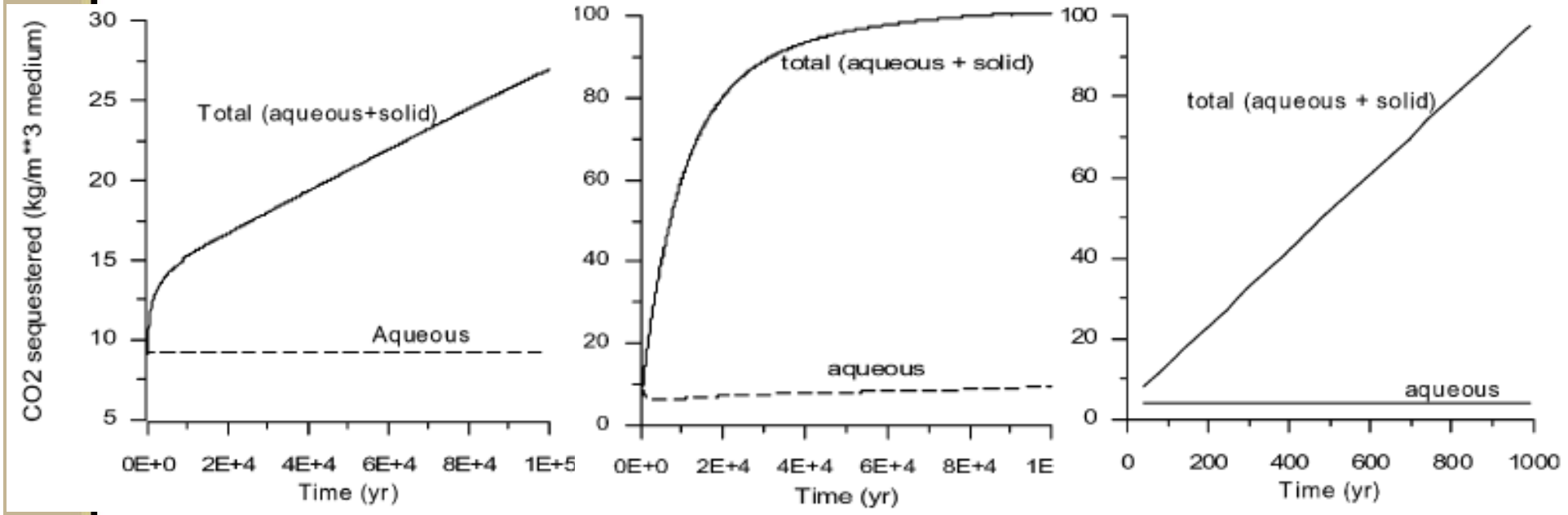
Mineral Trapping

Xu, Apps and Pruess (2004)

Fixed CO_2 pressure of 260 bars



Glauconitic sandstone
~0.2 g yr^{-1} m^{-3}

Gulf Coast sediments
~3 g yr^{-1} m^{-3}

Dunite
~100 g yr^{-1} m^{-3}

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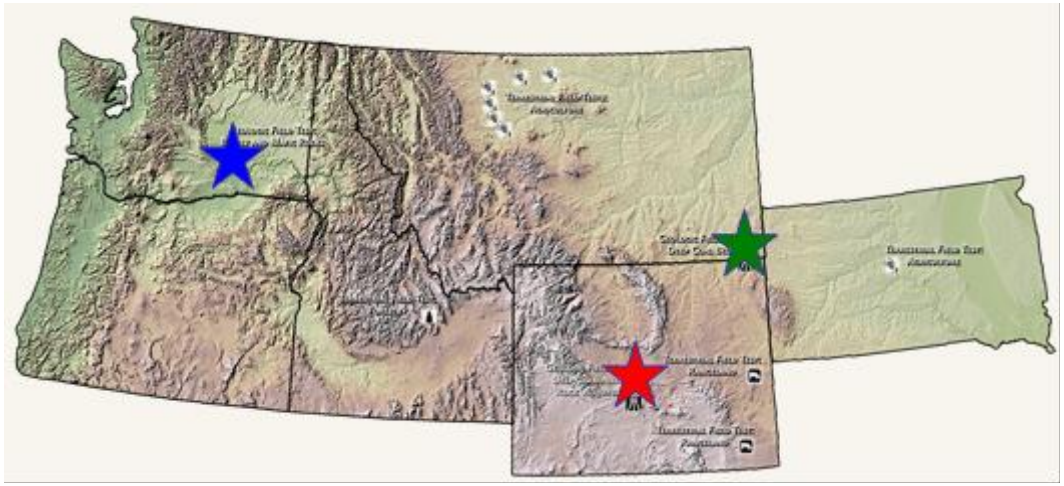
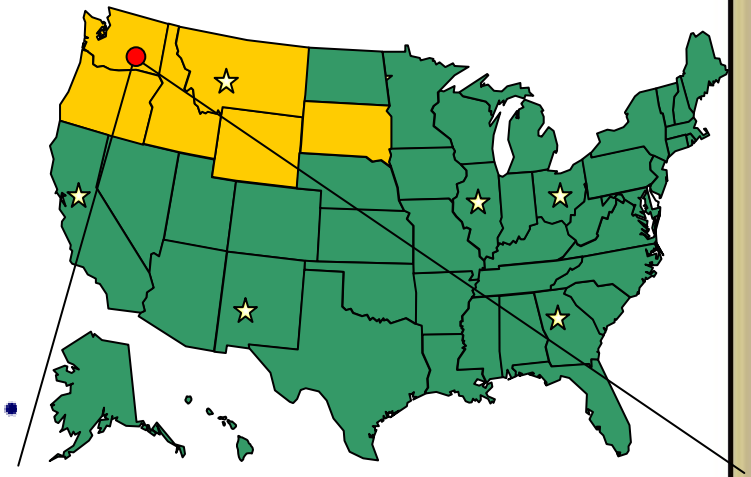
BSCSP Geologic Field Activities

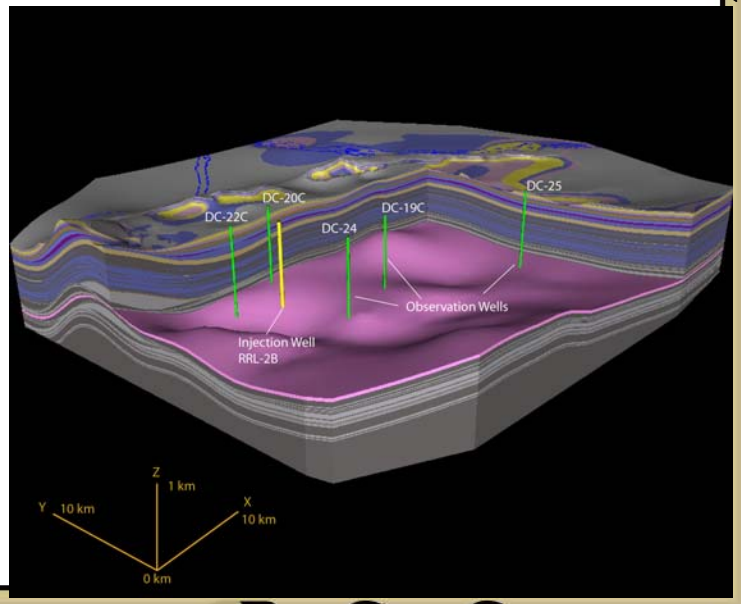
- **Basalt and Mafic Rock Field Validation Test**
  - **National Mafic Rock Atlas**
- **Reactive Carbonate Reservoir (Madison Formation) Field Validation Test**
- **Enhanced Coal Bed Methane Recovery and CO_2 Sequestration**



Basalt and Mafic Rock Field Validation Test

- 3000 MT of CO_2 transported by rail from refinery
- Utilize existing deep well infrastructure to minimize drilling costs for injection and monitoring
- Target is Grande Ronde basalt formation (1100 m depth)
- Post injection core sampling to verify mineralization reactions
- Validate supercomputer simulations of CO_2 dispersion, dissolution, and trapping in basalt using suite of geophysical, hydrologic, and tracer methods





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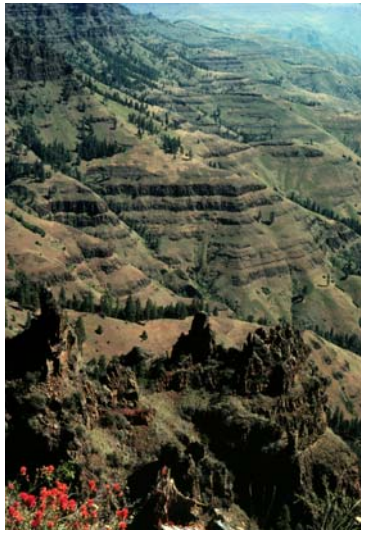
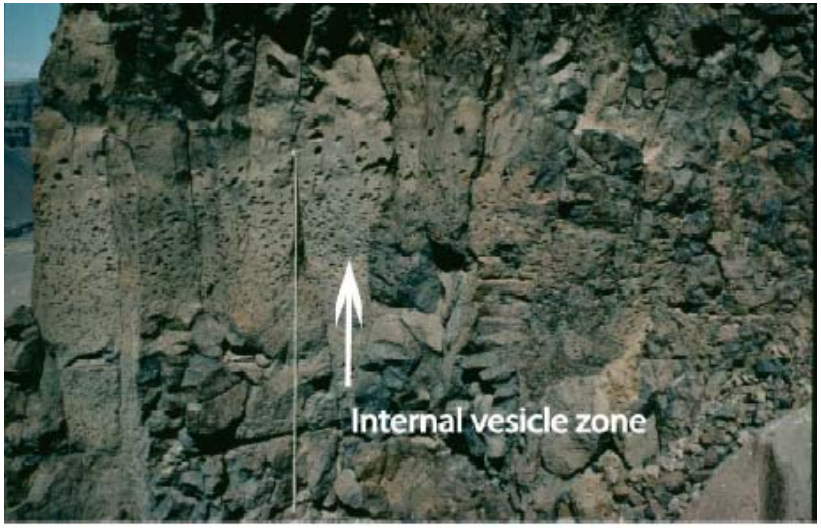
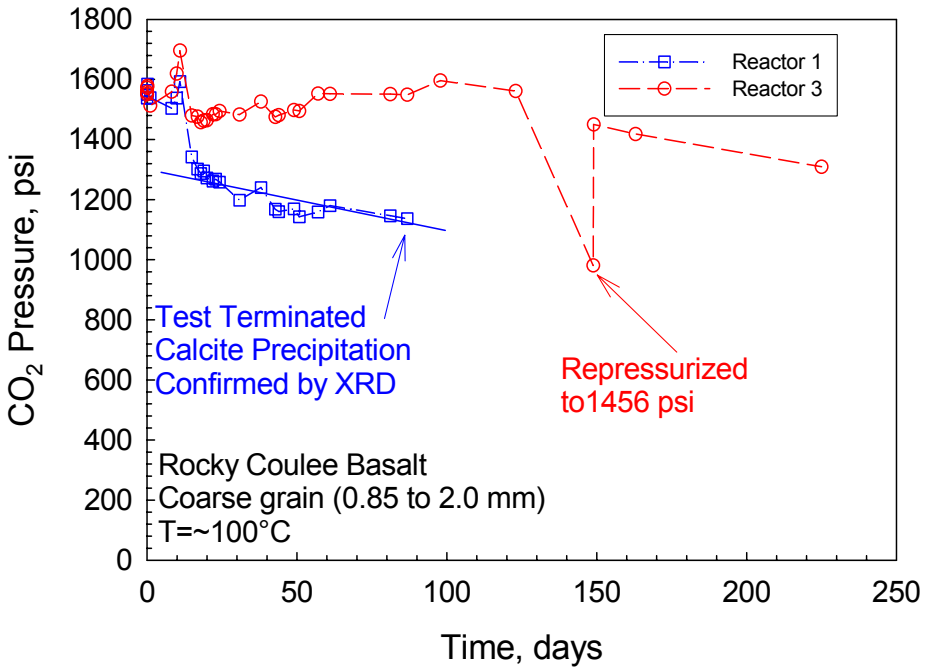
Rationale for Basalts





– Capacity and Retention
  - Columbia River Basalt Group covers 164,000 km^2, >174,000 km^3
  - Chemical makeup favorable for mineralization reactions
  - 3% of basalt suitable for injection
    – 100 $GtCO_2$ storage capacity

Supercritical CO_2 Pressure Cell Experiments with Columbia River Basalt



Long-term experiments showing transition from calcite to ankerite, $Ca(Fe, Mg, Mn)(CO_3)_2$

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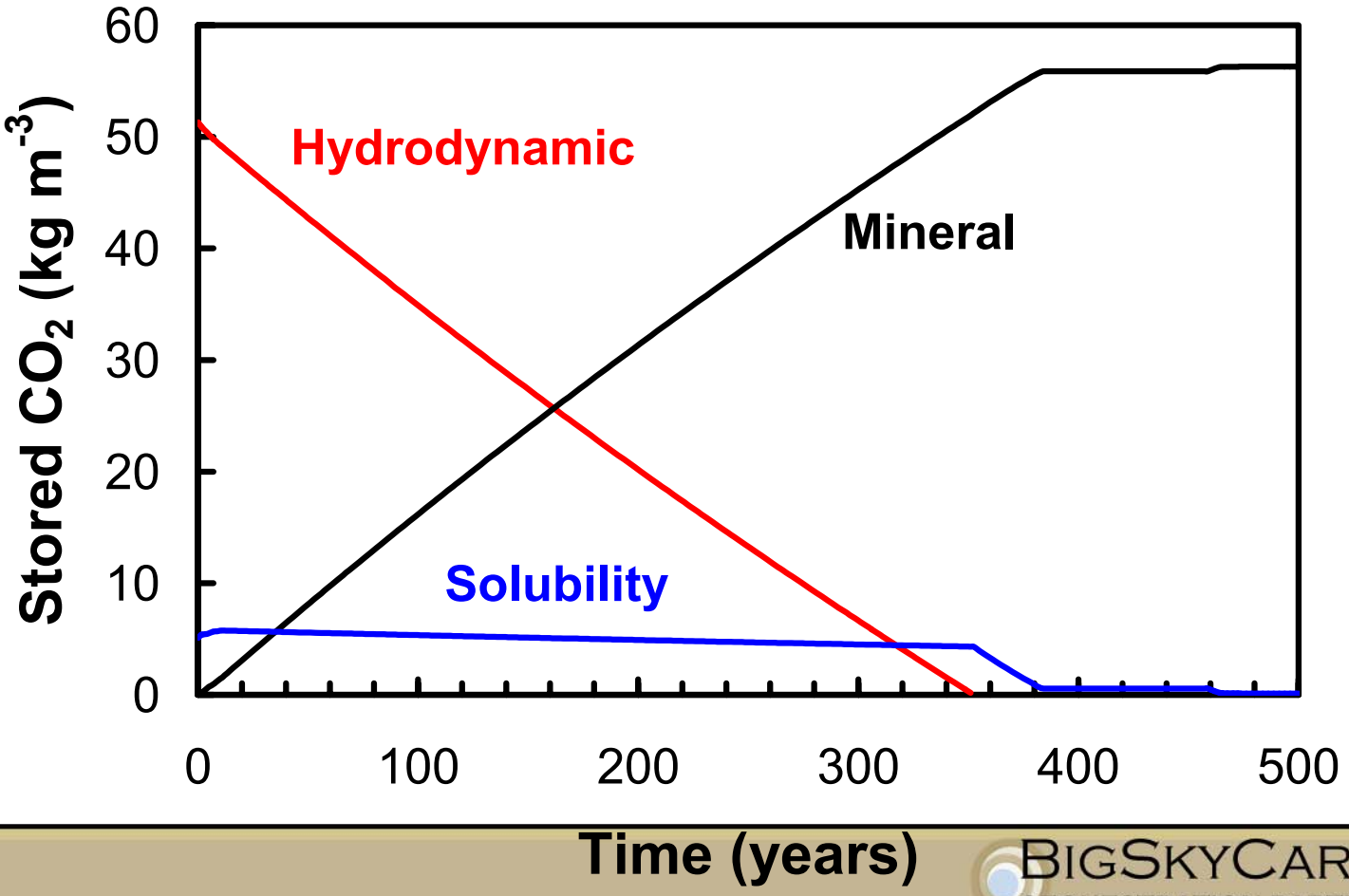
Hydrodynamic, Solubility, & Mineral Trapping



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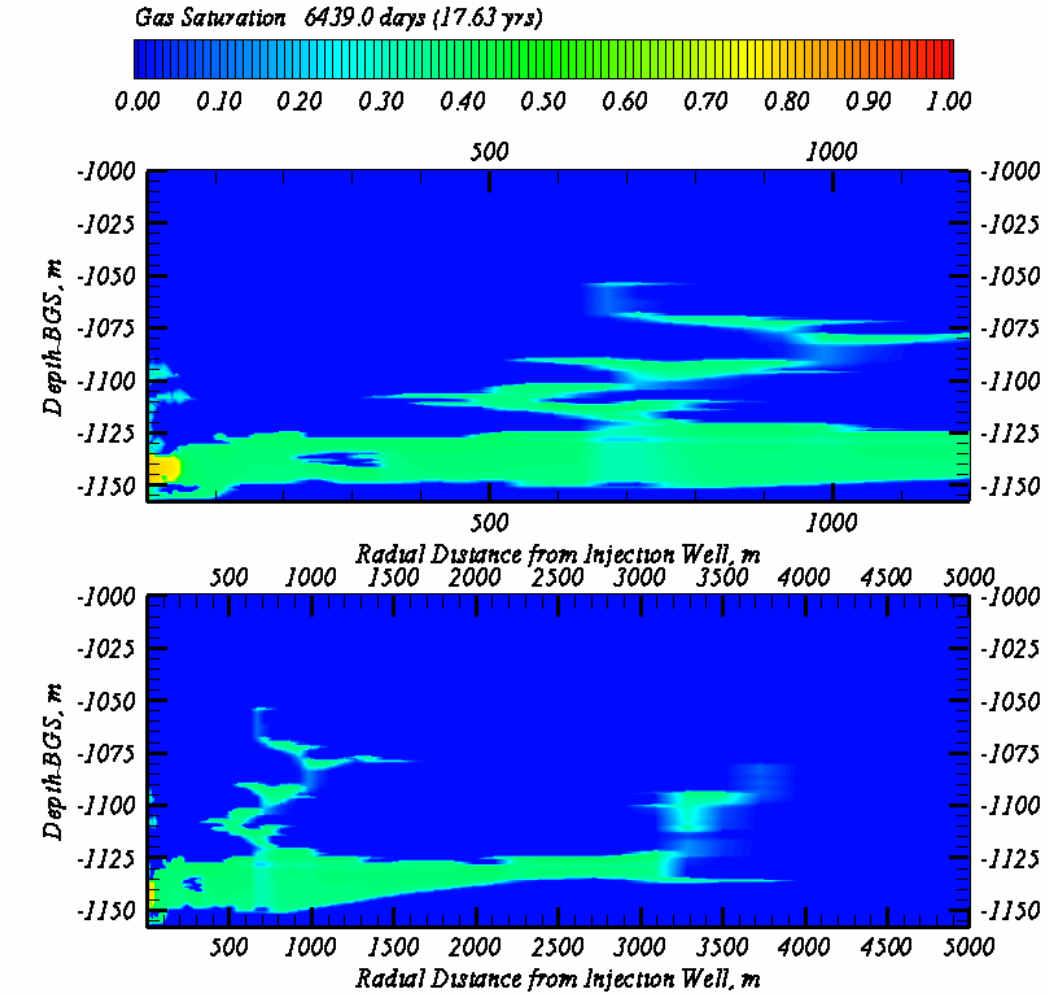
Supercomputer Simulation of CO_2 Injection in Grande Ronde Basalt



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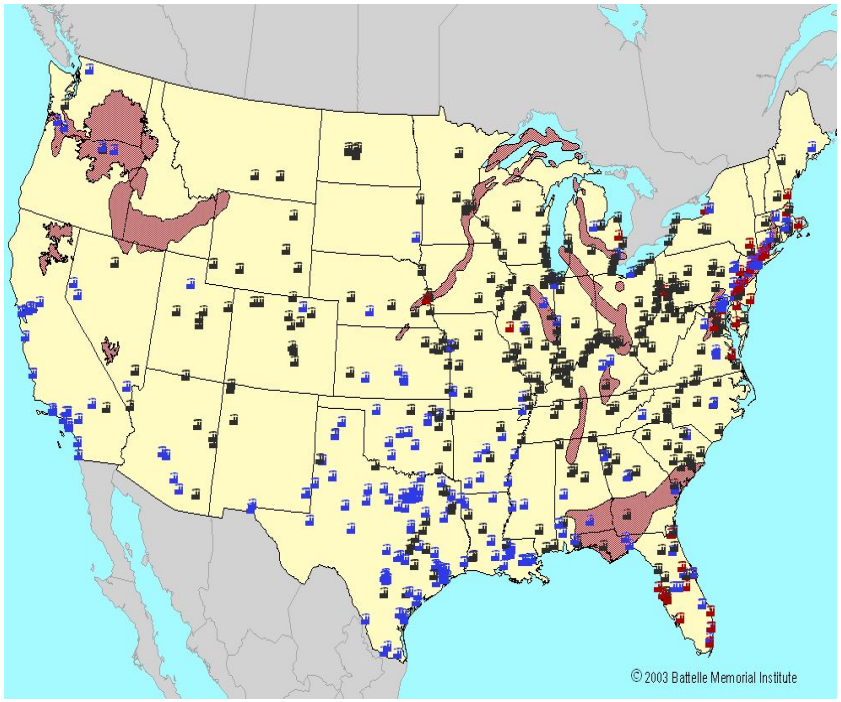
National Mafic Rock Atlas

- Develop a GIS-based tool that integrates
  - modeling studies
  - laboratory tests
  - pilot project insights
- Provides for transferablity of pilot results nationally and internationally



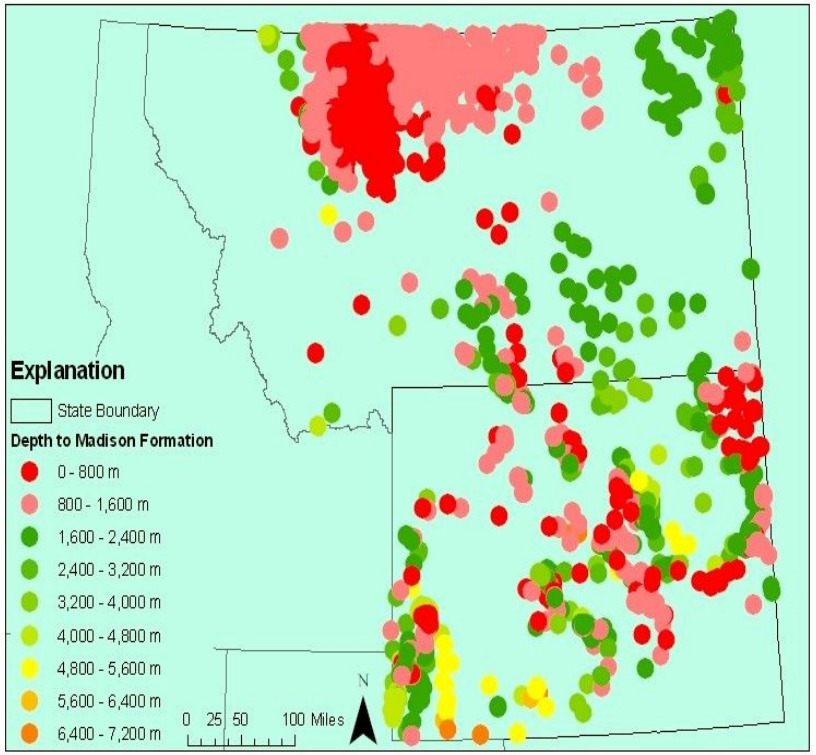
Many power plants are located near large basalt provinces
- Exist in regions with limited “conventional” capacity
- Prevalent in regions with large future electrical generation growth

Reactive Carbonate Reservoir (Madison Formation) Field Validation Test

- Regionally abundant carbonate rocks (dolomites and limestones) are highly reactive with CO_2

$CaMg(CO_3)_2 + 2CO_2 + 2H_2O \rightarrow Ca^{2+} + Mg^{2+} + 4HCO_3^-$

- Reactions should result in permeability and porosity increases



Depth to top of Madison Formation

Objective and Approach

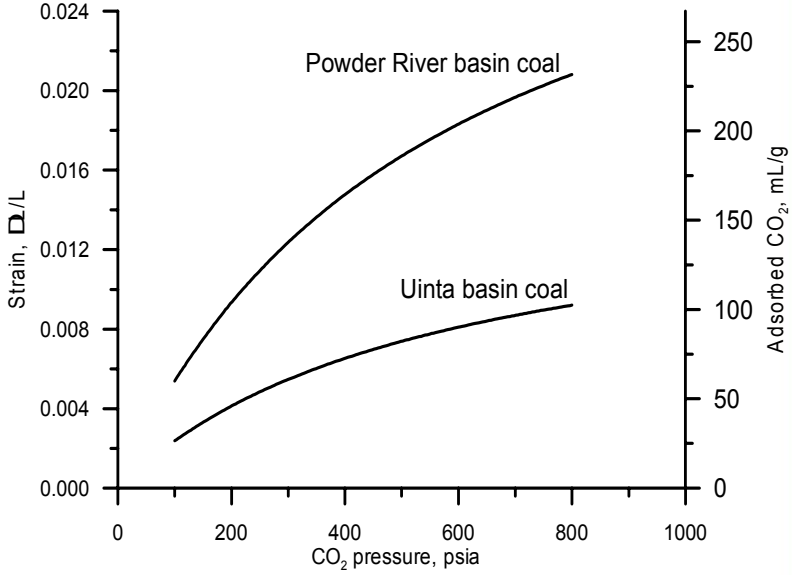
- Assess long-term CO_2 mineralization rates in a carbonate host reservoir (Madison Formation target)
- Collect core from reservoir that has undergone CO_2 EOR
  - long CO_2 exposure history
  - Compare to preinjection core
  - Validate predictive modeling of CO_2 injection

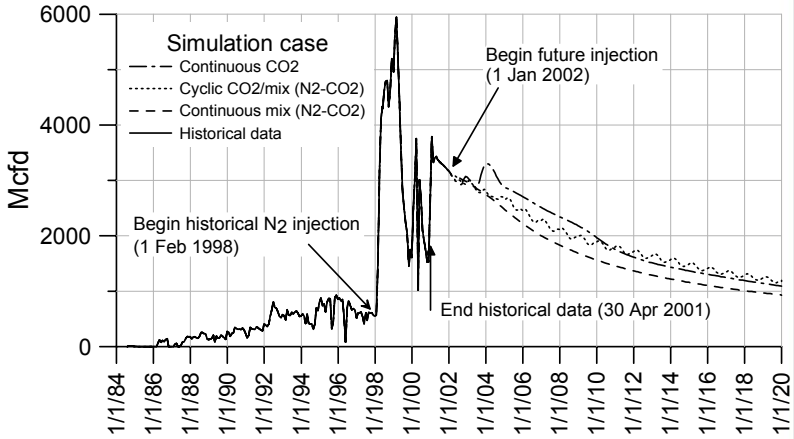
Modeling of CO_2 inject history

- Focus on the consequences of the long-term exposure of carbonate rocks to CO_2-rich fluids
- Conduct modeling studies to match the history of preinjection and post injection conditions
  - Changes in water chemistry
  - Changes in permeability and porosity
  - Quantify changes in carbon storage potential

Enhanced Coal Bed Methane Recovery and CO_2 Sequestration

- Recent work shows Powder River basin coals can adsorb twice as much CO_2 as Uinta basin coals
- Study various gas injection strategies
  - Economic evaluation
  - Reservoir simulation
- Attention will be given to impact of coal swelling on permeability changes





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